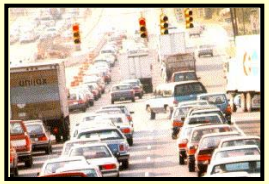








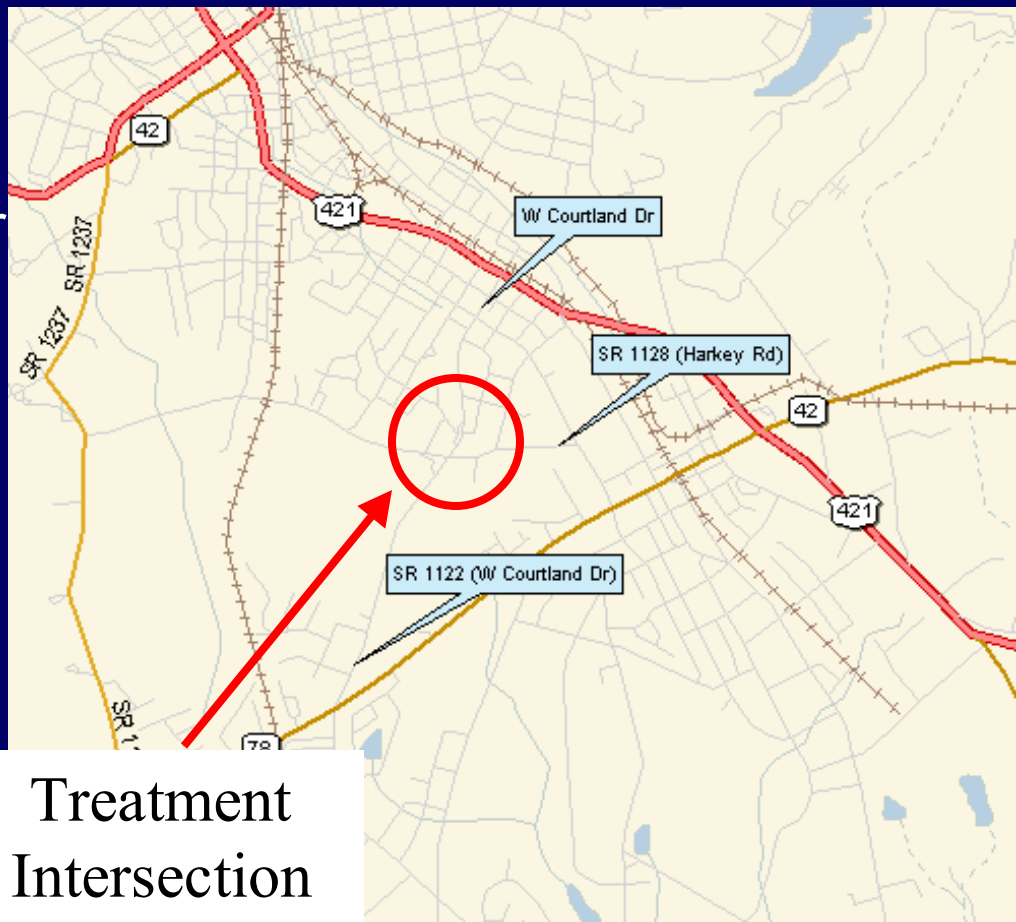



All-Way Stop Evaluation - 4 Legs (2)

All-Way Stop Evaluation (2)

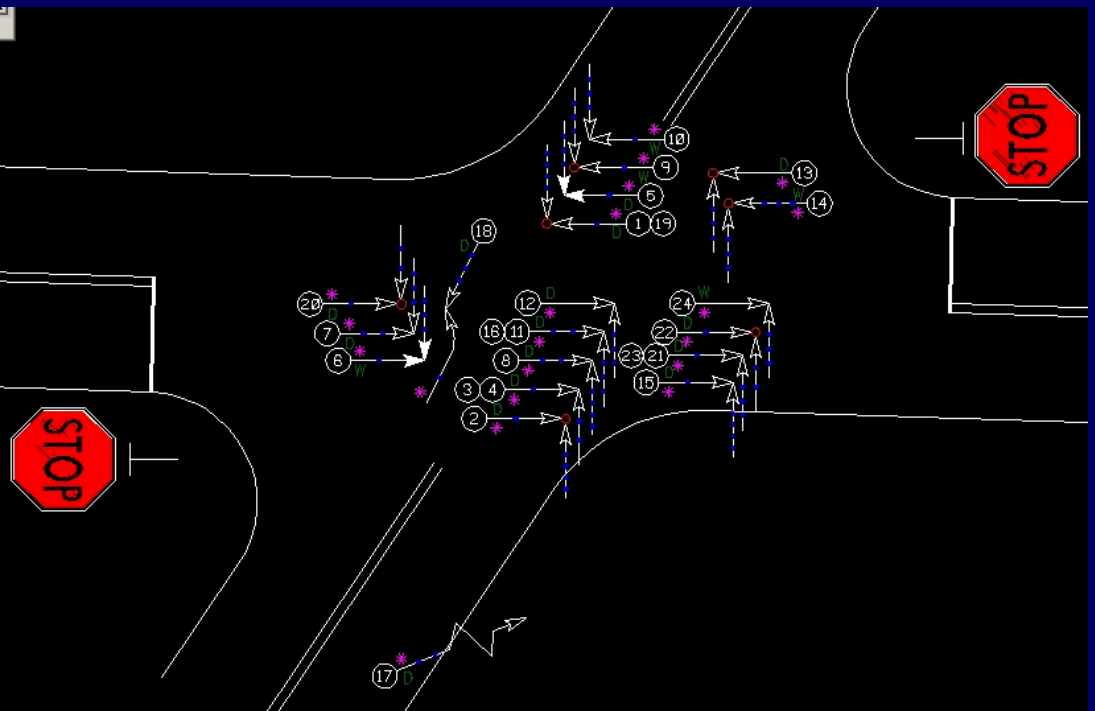
- Location:
  - SR 1117 (Harkey) at SR 1122 (Courtland) in Lee County || Log# 200512003
- Countermeasure:
  - Convert 2- Way Stop Control Intersection to 4-Way Stop Control With Overhead Flasher



Treatment Intersection

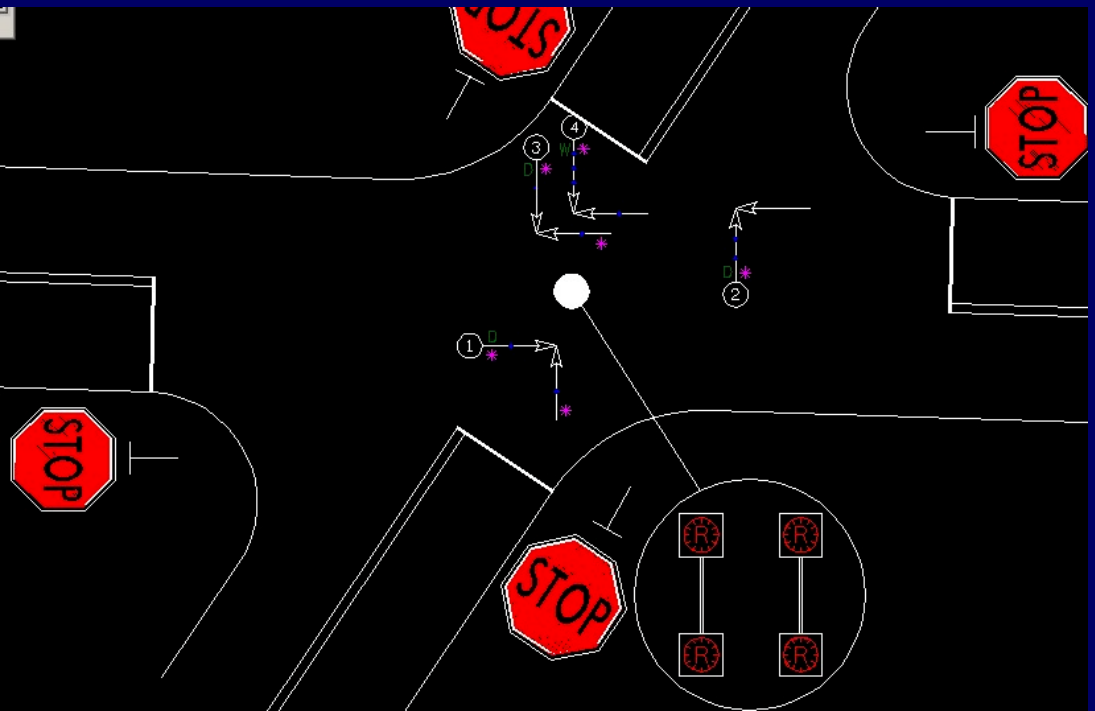
All-Way Stop Evaluation (2)

Before Collision Diagram



All-Way Stop Evaluation (2)

After Collision Diagram



All-Way Stop Evaluation (2)

Results

Treatment Information

	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	24	4	-83.3%
Total Severity Index	3.47	1.00	-71.2%
Target Crashes	23	4	-82.6%
Target Crashes	3.57	1.00	-72.0%
Volume	8100	8500	4.9%

Target Crash Information

	Before	After	Percent Reduction (-)/ Percent Increase (+)
Fatal Injury Crashes	0	0	N/A
Non-Fatal Injury Crashes	8	0	-100.0%
Total Injury Crashes	8	0	-100.0%
Night Crashes	2	0	-100.0%
Wet Crashes	5	1	-80.0%

- Total Crashes
  - Decreased 83 %
- Target Crashes
  - Decreased 83 %
- Total Crash Severity Index
  - Decreased 71 %
- Target Crash Severity Index
  - Decreased 72 %

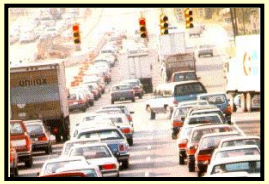





All Way Stop Evaluation - 3 Legs (3)

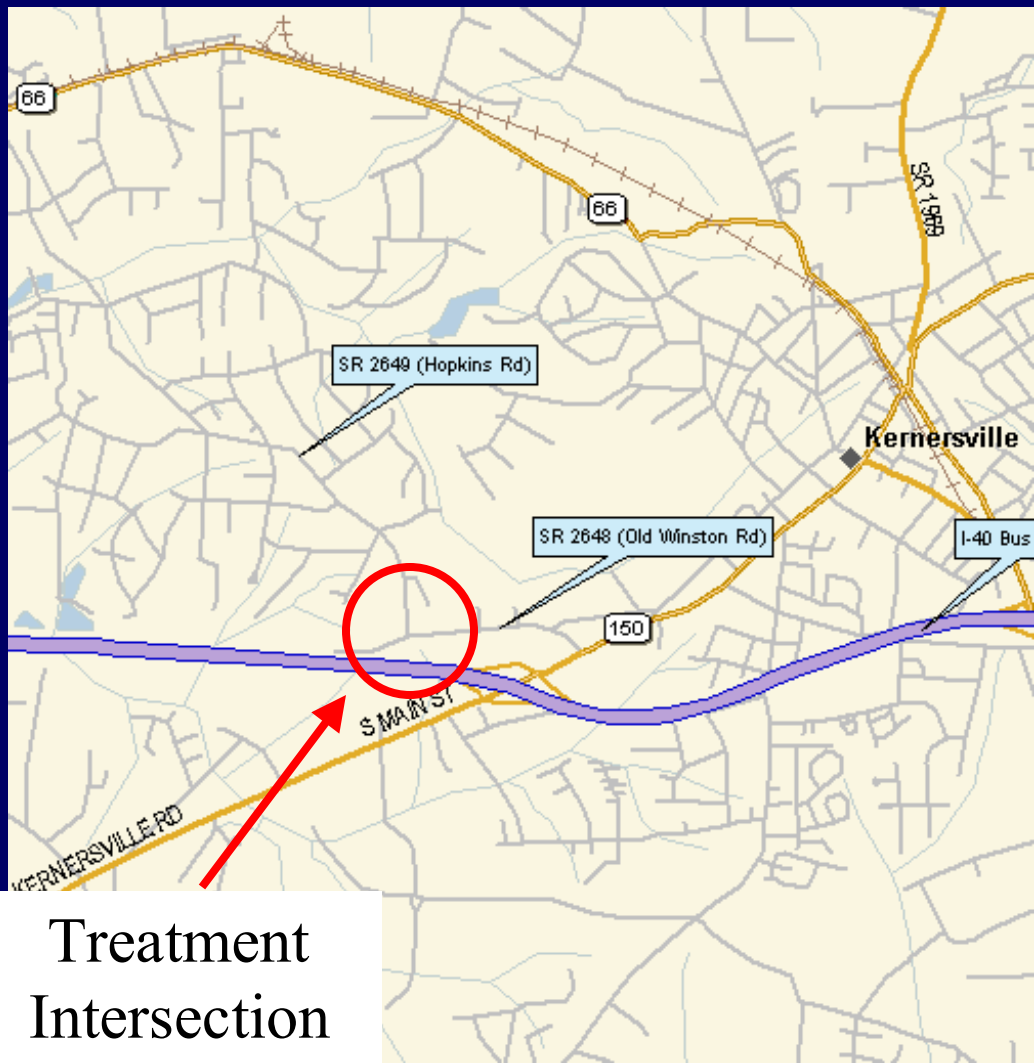





All-Way Stop Evaluation (3)

- Location:
  - SR 2648 (Old Winston) at SR 2649 (Hopkins) in Forsyth County || SS# 09-00-204
- Countermeasure:
  - All-Way Stop Control, Center Turn Lane, Right Turn Slip Lane - Cost: $368,600



Treatment Intersection

All-Way Stop Evaluation (3)


SR 2648 - Look West

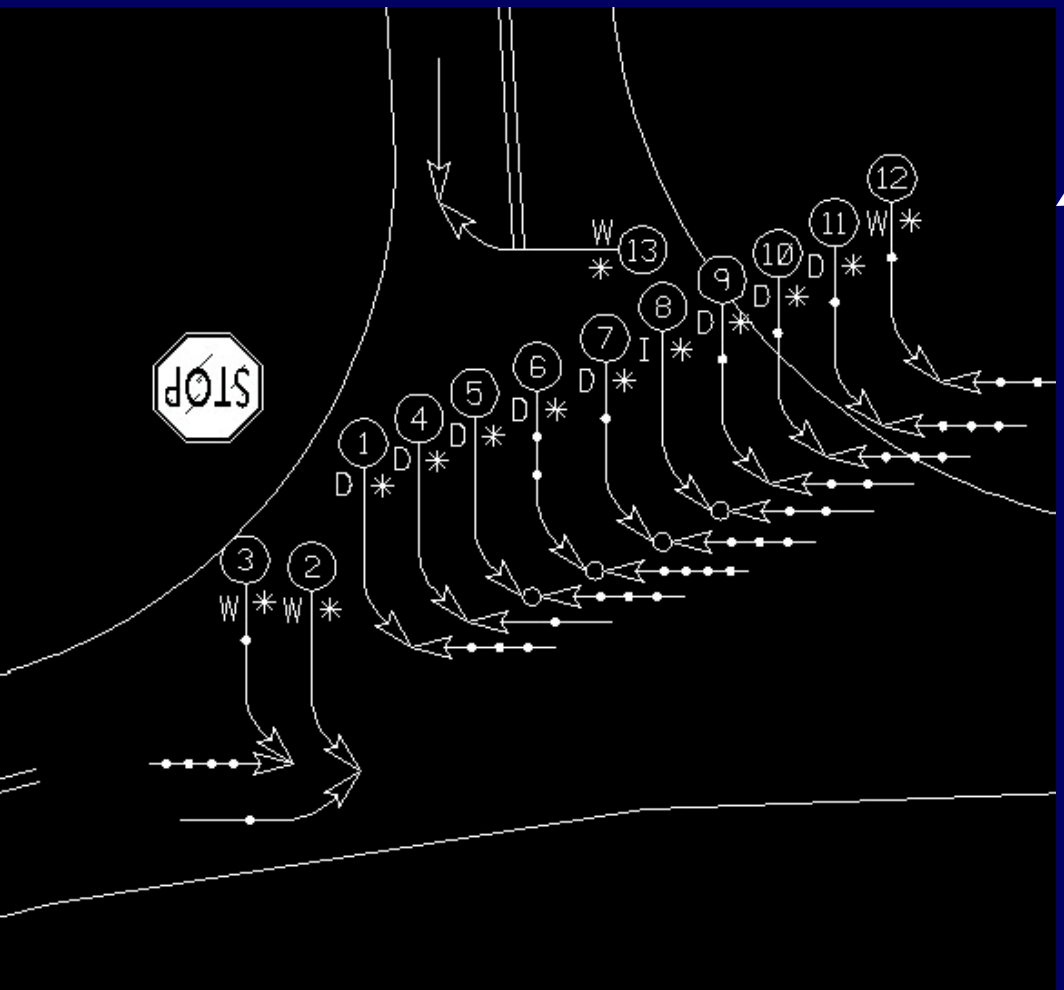

SR 2648 - Look East

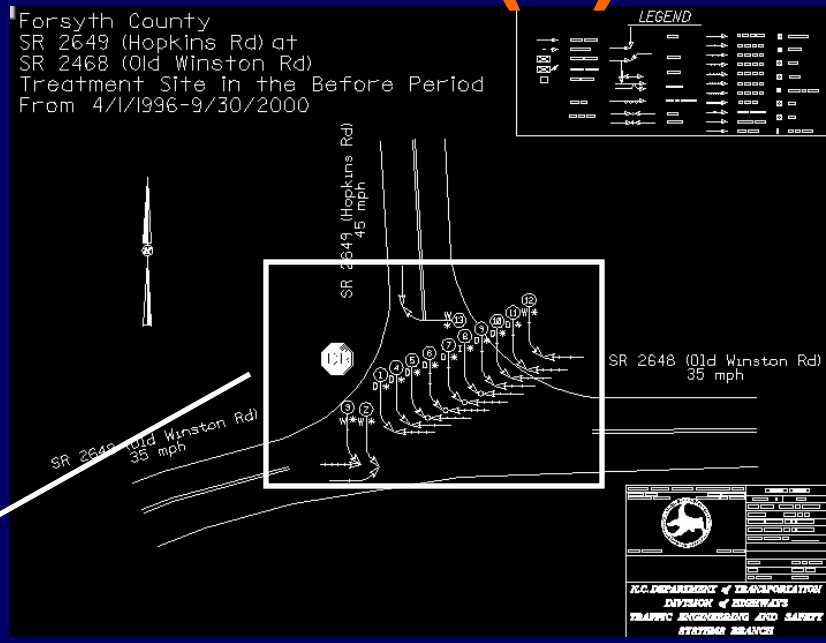

SR 2649 - Drive South

SR 2649 - Drive South

All-Way Stop Evaluation (3)

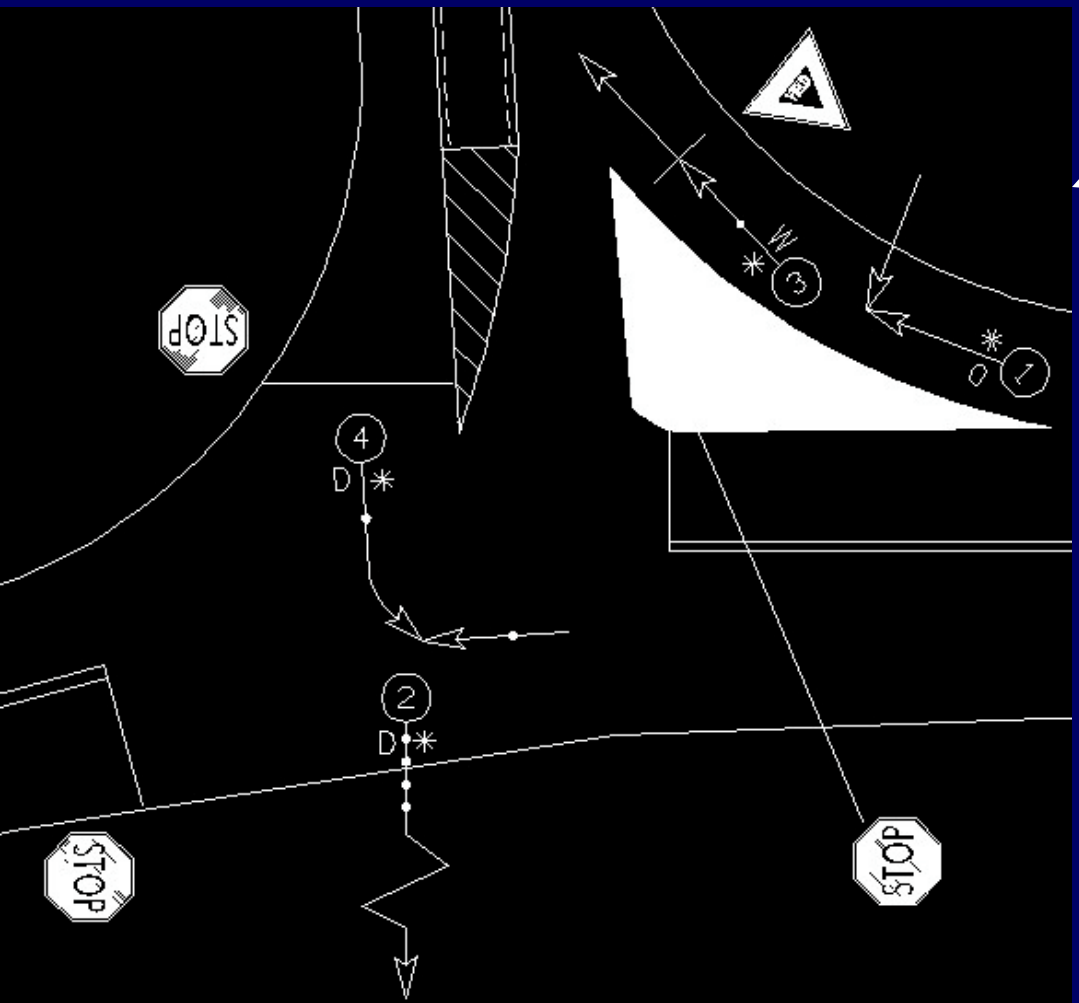
Before Collision Diagram

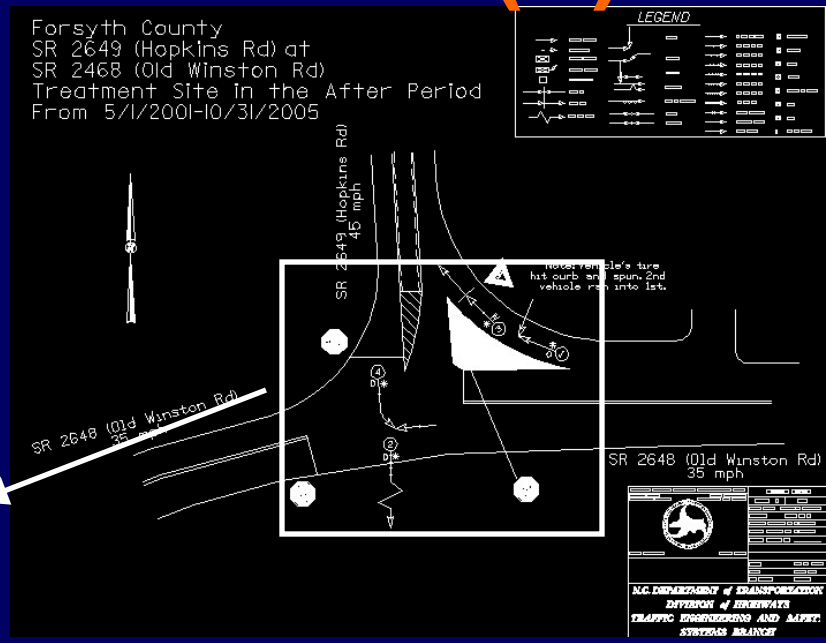




All-Way Stop Evaluation (3)

After Collision Diagram





All-Way Stop Evaluation (3)

Results

Table 1. Treatment Information for Intersection	Before Period	After Period	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	13	4	-69.2
Total Severity Index	13.8	1	-92.8
Total Target Crashes	10	1	-90.0
Target Severity Index	17.64	1	-94.3
Volume	10,600	11,500	8.5

Table 2. Treatment Information for Strip on Hopkins Rd	Before Period	After Period	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	2	2	0
Total Severity Index	4.7	1	-78.7
Total Target Crashes	1	1	0
Target Severity Index	1	1	0
Volume	10200	10600	3.9

- Total Crashes
  - Decreased 69 %
- Target Crashes
  - Decreased 90 %
- Total Crash Severity Index
  - Decreased 93 %
- Target Crash Severity Index
  - Decreased 94 %

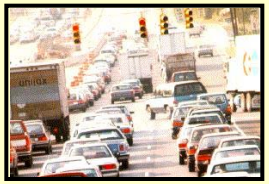








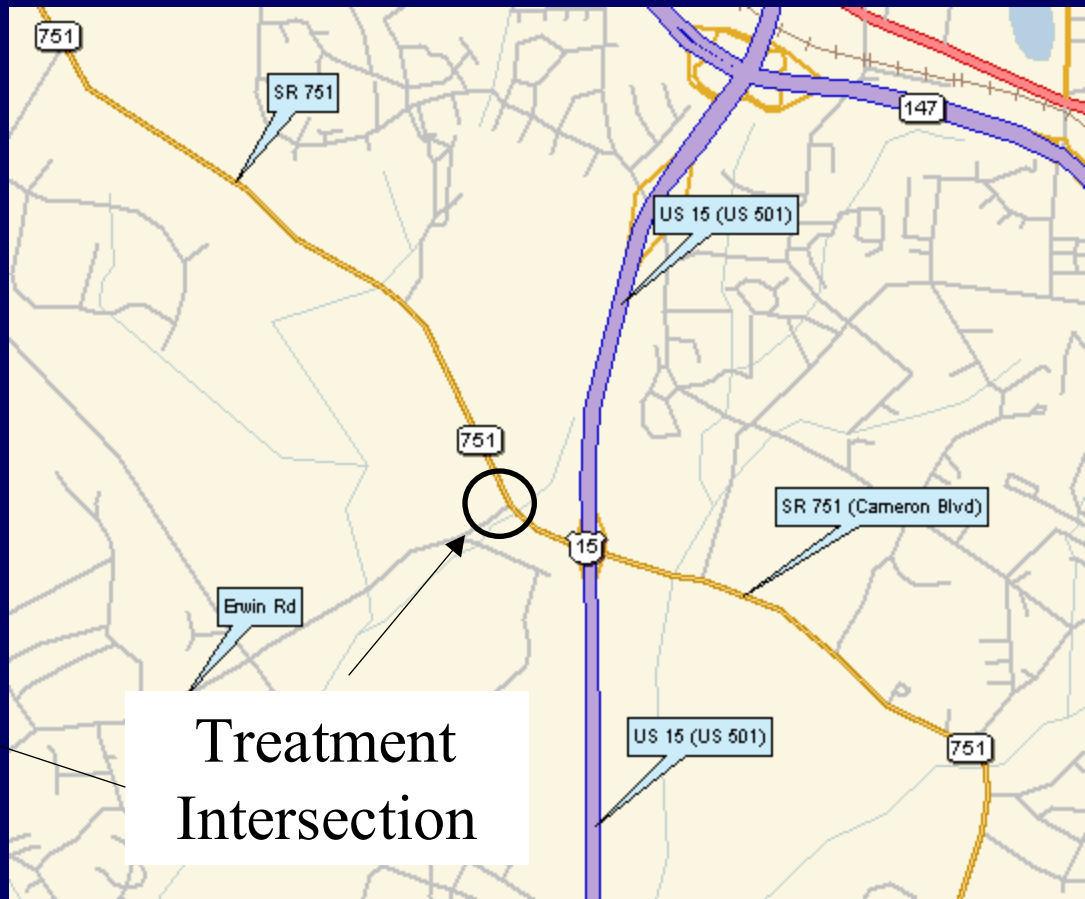



Roundabout Evaluation

Roundabout Evaluation

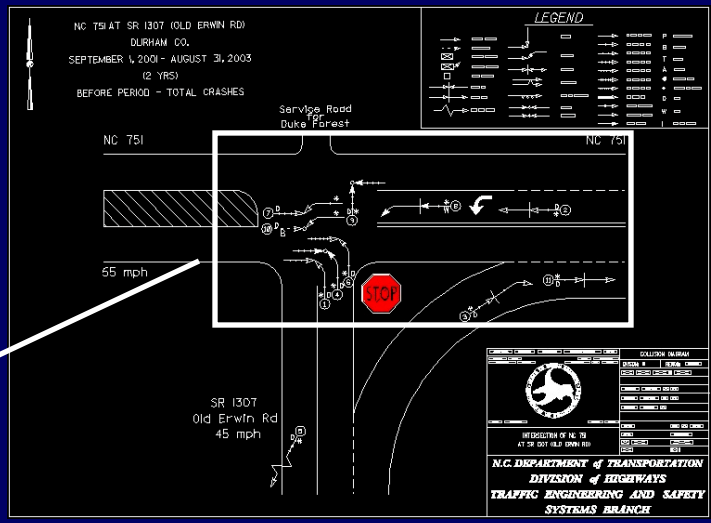
- Location:
  - NC 751 at SR 1307 (Old Erwin Rd) in Durham County
- Countermeasure:
  - Convert Four Leg Stop Control Intersection to a Roundabout
  - Cost: $265,000

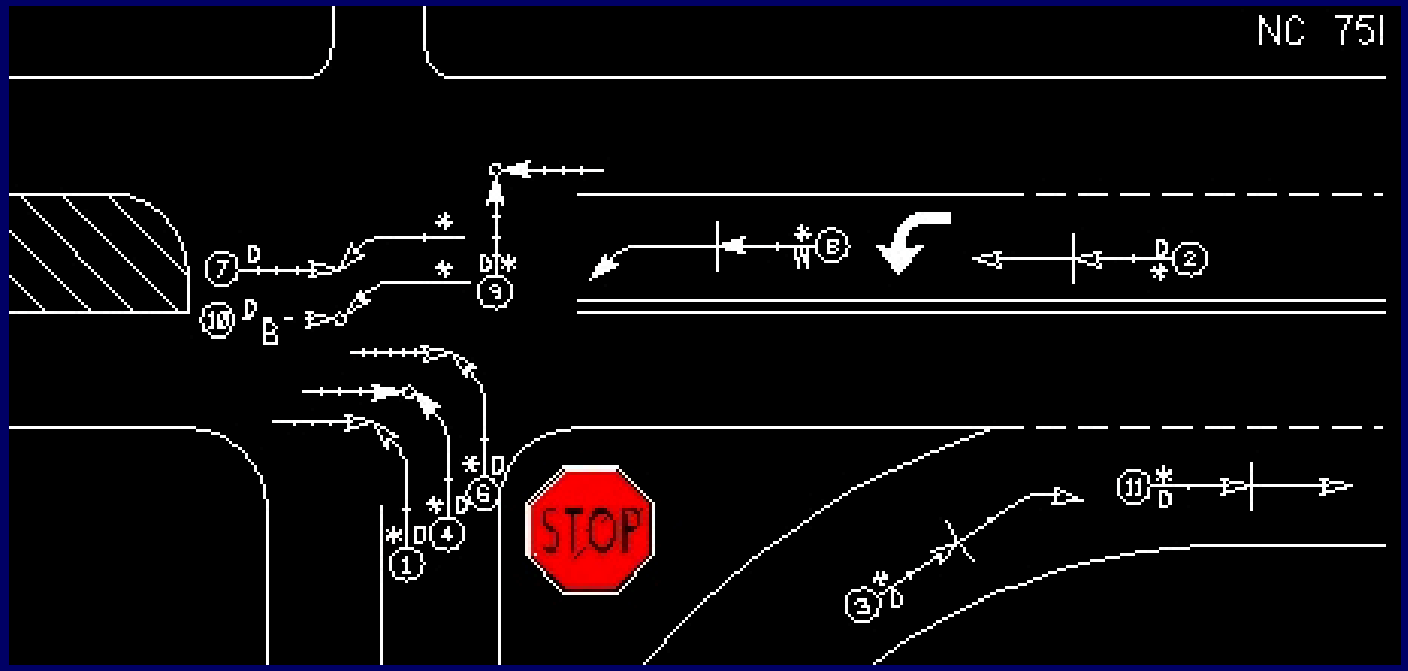


Roundabout Evaluation

Roundabout Evaluation

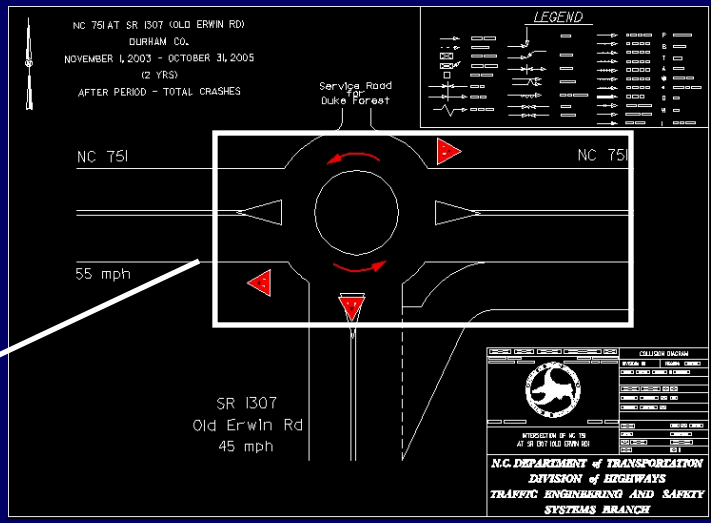
Before Collision Diagram

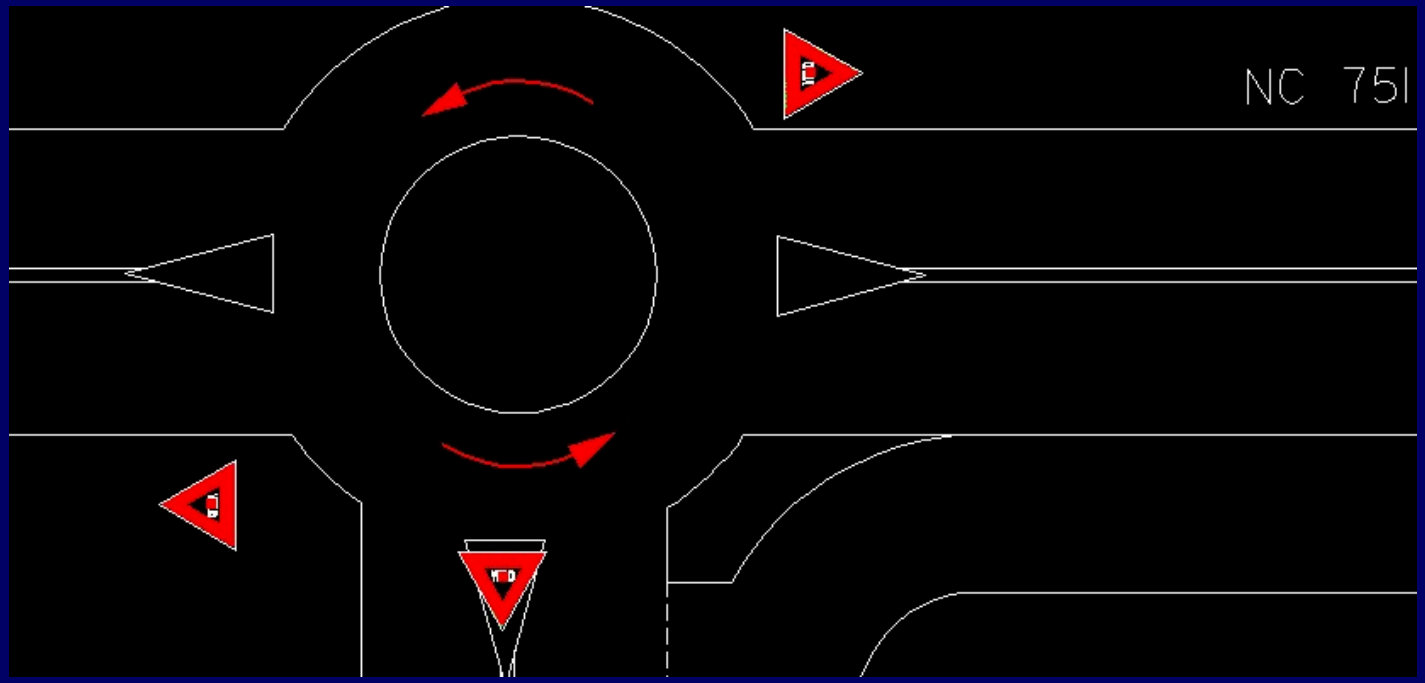




Roundabout Evaluation

After Collision Diagram





Roundabout Evaluation

Results

Treatment Information	Before	After	Percent Reduction (-)/ Percent Increase (+)
Total Crashes	11	0	-100.0%
Total Severity Index	3.02	0	-100.0%
Target Crashes	5	0	-100.0%
Target Severity Index	3.96	0	-100.0%
Volume	16,100	15,300	-5.0%

Target Crash Information	Before	After	Percent Reduction (-)/ Percent Increase (+)
Fatal Injury Crashes	0	0	N/A
Non-Fatal Injury Crashes	2	0	-100.0%
Total Injury Crashes	2	0	-100.0%
Night Crashes	2	0	-100.0%
Wet Crashes	0	0	N/A






Crash Modification Factor Development

Brian G. Murphy, PE

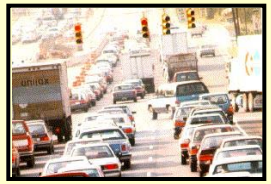
North Carolina DOT - Traffic Safety Unit

Traffic Engineering Conference for Operations and Safety

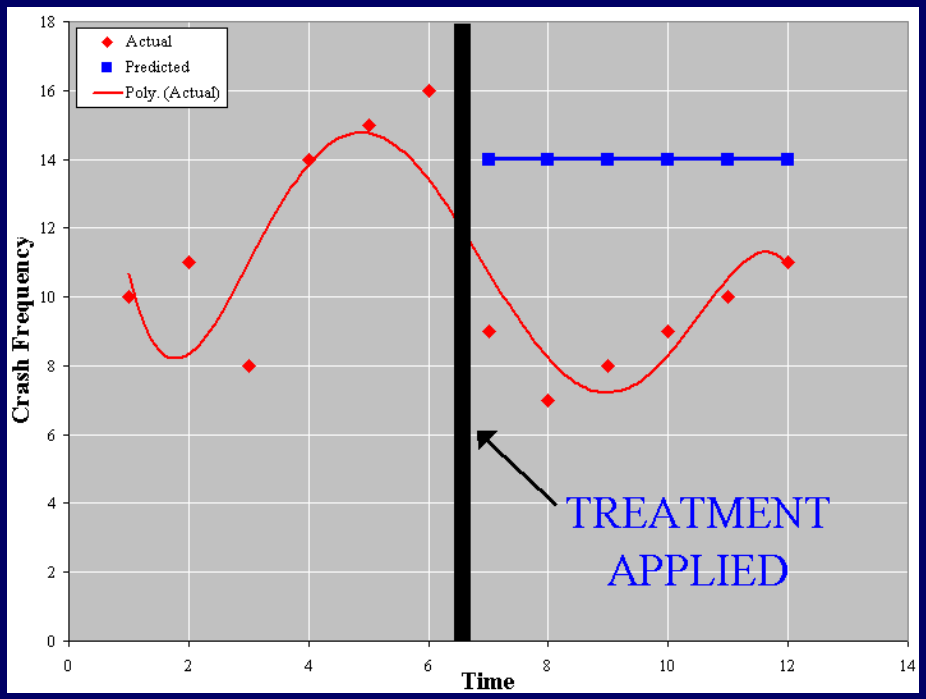
August 24, 2006






What is a CMF?



	Time Period												Sum - After Period
	1	2	3	4	5	6	TREATMENT APPLIED	7	8	9	10	11	12	
Actual Crashes	10	11	8	14	15	16		9	7	8	9	10	11	54
Predicted	--	--	--	--	--	--		14	14	14	14	14	14	84

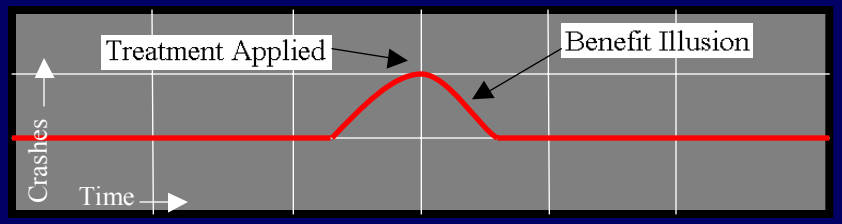
$$CMF = \frac{\text{Actual After Period Crashes}}{\text{Predicted After Period Crashes}} = \frac{54}{84} = 0.64 \Rightarrow 36\ \%$$

Reduction in Crashes

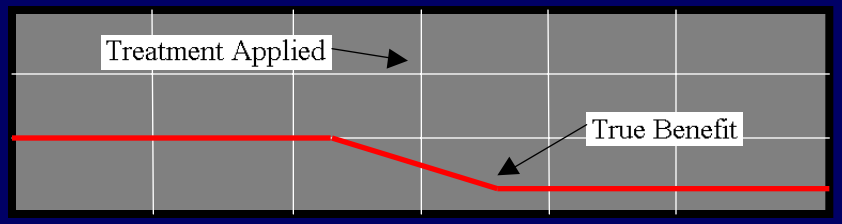
Regression to the mean

- RTM - A site will return to it's long term mean crash frequency after an extraordinary year

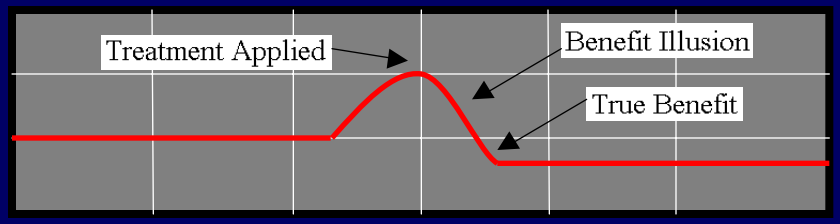
RTM with Benefit Illusion



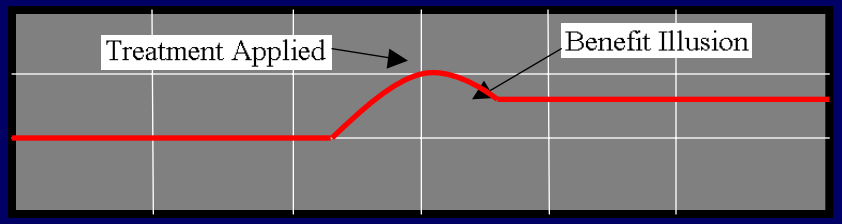
No RTM with True Benefit



RTM with True Benefit



RTM with Disbenefit



Regression to the mean

- Real or Theoretical?

Number of Crashes	Number of Sites with 'X' Number of Crashes	Number of Crashes at These Sites In the Following Three Years	Did These Sites Regress to the Mean?
X	n(X)		
0	32	1.3	YES
1	39	2.0	YES
2	25	2.5	YES
3	24	3.8	NO
4	17	4.6	NO
5	7	4.6	YES
6	8	5.0	YES
7	10	6.6	YES
8	3	6.7	YES
9	1	5.0	YES
10	2	6.0	YES
11	2	4.0	YES
Total	**170**		
Mean	**2.69**		

170 Rural, 4-Leg Intersection

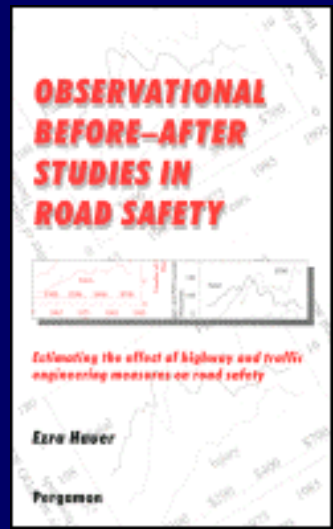
NO TREATMENTS!

Regression to the Mean Does Exist

More Pronounced in Extreme Situations

Safety Evaluation Types

- Naïve Before and After Studies
  - Easiest to do
  - Biases: History, maturation, regression to the mean
- Comparison Sites
  - Attempts to account for “other factors” - Ex. Weather, changes in veh fleet, legislation changes, etc.
  - Bias: Never as good as the sites we chose to treat
- Emperical Bayes Methods
  - Difficult to do
  - Attempts to account for regression to the mean
    - Crash history at site
    - Crash history at large pool of reference sites



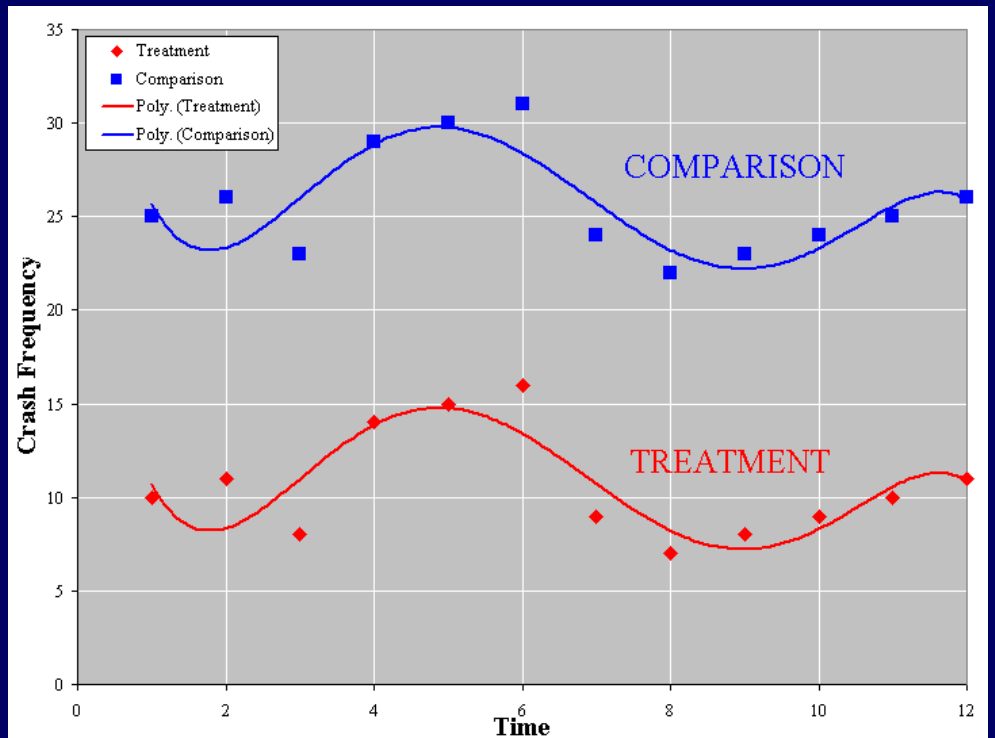
Evaluation Types

- Naïve Before and After Studies
  - Easiest to do
  - Biases: History, regression to the mean, etc.
  - Basic Assumption:
    - Nothing changed at site from the before to the after period except for the countermeasure
    - Predicted After Period Crashes = Actual Before Period Crashes

$$CMF = \frac{\text{Actual After Period Crashes}}{\text{Predicted After Period Crashes}} = \frac{\text{Actual After Period Crashes}}{\text{Actual Before Period Crashes}}$$

Evaluation Types

- Before and After Studies Using Comparison Sites
  - Attempts to account for "other factors" - Ex. Weather, changes in veh fleet, legislation changes, etc.
  - Bias: Never as good as the sites we chose to treat
  - Very difficult to find good comparison sites

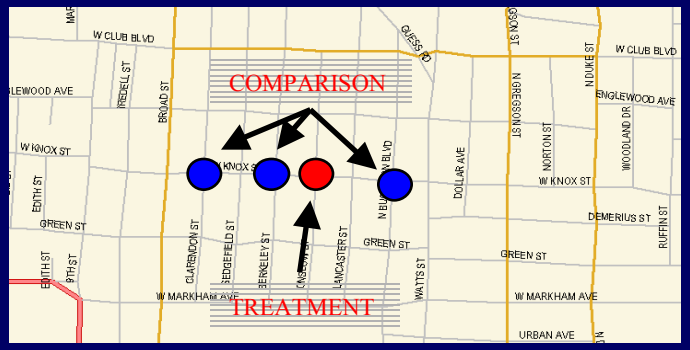


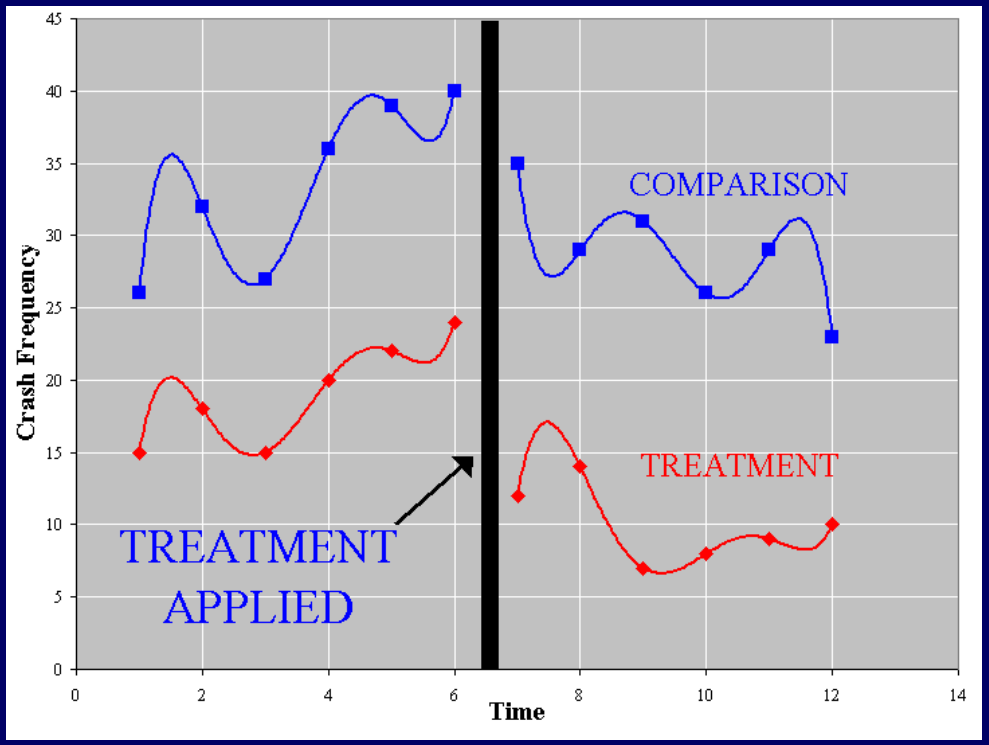
Time	Treatment	Comparison
Before	T_B	C_B
After	T_A	C_A

$$\text{Odds Ratio} = \frac{C_B/C_A}{T_B/T_A}$$

Evaluation Types

- Before and After Studies Using Comparison Sites





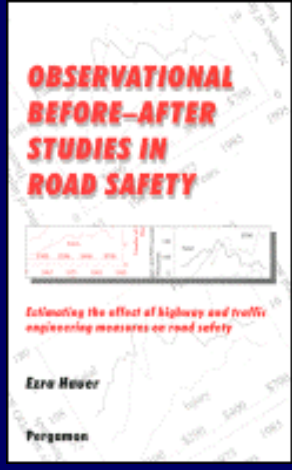
Time	Treatment		Comparison	
Before	T_B	114	C_B	200
After	T_A	60	C_A	173

	Time Period						TREATMENT APPLIED						Sum - Before Period	Sum - After Period
	1	2	3	4	5	6		7	8	9	10	11	12	
Treatment Crashes	15	18	15	20	22	24		12	14	7	8	9	10	114	60
Comparison Crashes	26	32	27	36	39	40		35	29	31	26	29	23	200	173

Odds Ratio (Comparison Analysis) $= \frac{C_B/C_A}{T_B/T_A} = \frac{201/233}{114/62} = 0.61$ ➡ 39 % Reduction

Naïve B/A $= \frac{T_A}{T_B} = \frac{60}{114} = 0.53$ ➡ 47 % Reduction

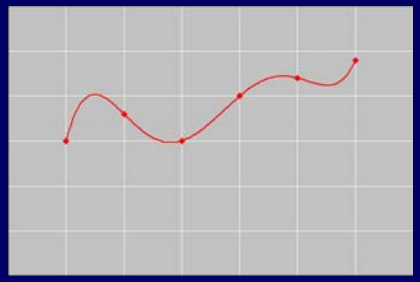
Evaluation Types



- Emperical Bayes Methods
  - Difficult to do
  - Attempts to account for regression to the mean
    - Two clues that can be used to predict what safety would have been had no countermeasure been installed

Clue #1

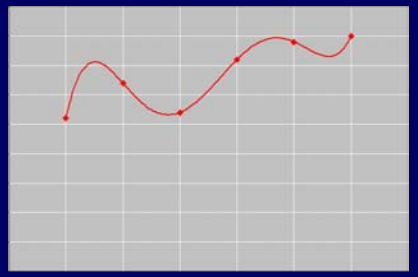
Crash History at Treatment Site



Weight → $1 - \alpha$

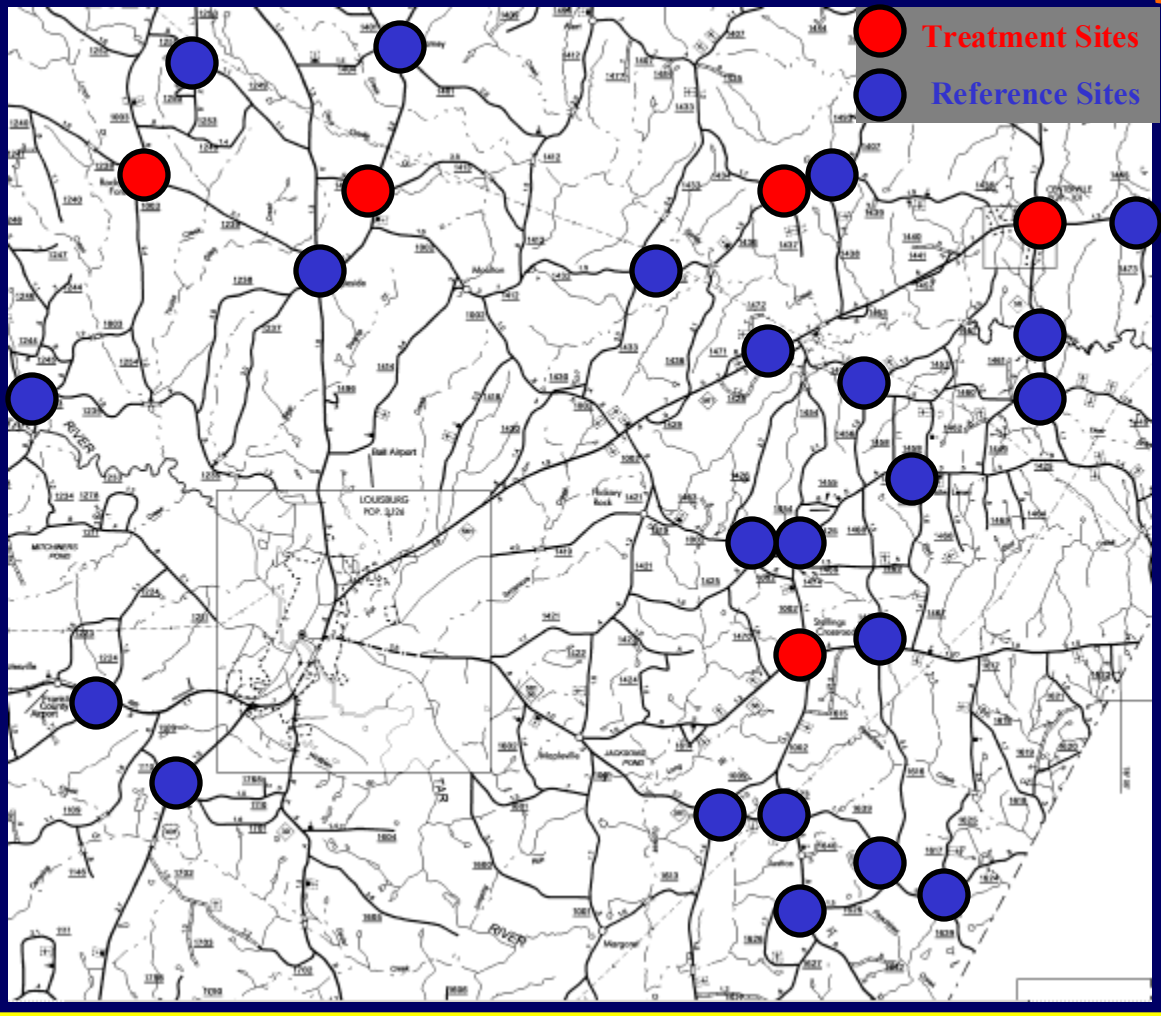
Clue #2

Crash History at Large Pool Of Reference Sites



α

Evaluation Types



Treatment			
	Before	After	Weight
	11	6	$1-\alpha = 0.62$

Reference			
	Average	Variance	Weight
	2.7	4.34	$\alpha = 0.38$

Predicted Crashes = (α)(Average Crashes on Reference Sites) + $(1-\alpha)$(Crashes at Treatment Site)

Predicted Crashes = $(0.38)(2.7) + (1-0.38)(11) = 7.85$ **SAY 8**

$$\text{CMF} = \frac{\text{Actual After Period Crashes}}{\text{Predicted After Period Crashes}} = \frac{6}{8} = 0.75$$

Crash Modification Factors

- Goal:
  - Develop crash modification factors based on North Carolina crash data
    - Reflects roadway / driver / weather / reportability conditions in North Carolina
    - Reflects decisions that Traffic Engineers in North Carolina are making

Flasher Evaluation

- Site Criteria
  - Rural
  - Intersection of two two-lane roads
  - No turn lanes
  - STOP sign control
  - At least three years of ‘after’ period crash data available
- Resulted in 34 Treatment Sites

Flasher Evaluation

- Naïve Before and After

	Before Period Crashes	After Period Crashes	Naïve Crash Reduction Factor
Total	534	482	10% +/- 6%
Injury	323	277	15% +/- 7%
Severe Injury	60	21	66% +/- 9%
Frontal Impact	438	392	11% +/- 6%
Run Through	103	52	50% +/- 8%

Flasher Evaluation

- Before and After Using Safety Performance To Predict After Period Crashes

$$N = C_i e^{(-9.34 + 0.60 \ln(ADT1) + 0.61 \ln(ADT2))}$$

Where:

C_i = Local Calibration Factor = 1.86
ADT1 = Average Daily Volume on Major Road
ADT2 = Average Daily Volume on Minor Road

	Actual After Period Crashes	Predicted After Period Crashes	SPF Crash Reduction Factor
Total	482	426	+13% +/- 8%

* A Positive Crash Reduction Factor Indicates an Increase in Crashes

Flasher Evaluation

- Emperical Bayesian Methods
  - Reference Sites
    - Used same criteria as treatment sites
    - 170 sites chosen

	Actual After Period	Predicted After Period	EB Crash Reduction Factor
Total	482	421	+14% +/- 7%
Injury	277	230	+20% +/- 9%
Severe Injury	21	26	19% +/- 19%
Frontal Impact	392	329	+19% +/- 8%
Run Through	52	53	2% +/- 16%

* A Positive Crash Reduction Factor Indicates an Increase in Crashes

Flasher Evaluation

- Emperical Bayesian + Traffic Adjustment Factor
  - Two Biggest Threats to This Particular Study
    - Regression to the Mean
      - Sites picked because of crash history
    - Increase in Traffic Volume
      - Average 27% Increase

	Actual After Period	Predicted After Period	Crash Reduction Factor
Total	482	548	12% +/- 6%
Injury	277	301	9% +/- 8%
Severe Injury	21	34	40% +/- 17%
Frontal Impact	392	430	9% +/- 7%
Run Through	52	69	26% +/- 14%

* A Positive Crash Reduction Factor Indicates an Increase in Crashes

Flasher Evaluation

Recommended Crash Reduction Factors for Overhead Flashers Installed at Rural, 4-Leg Intersections of 2-Lane Roads

Total Crashes	12%
Injury Crashes	9%
Severe Injury Crashes	40%
Frontal Impact Crashes	9%
“Ran Stop Sign” Crashes	26%

Contact Information

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Traffic Safety Unit Website:
http://www.ncdot.org/doh/preconstruct/traffic/TSU/default.html